PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B

Phil. Trans. R. Soc. B (2009) **364**, 1443–1447
doi:10.1098/rstb.2008.0327

Assessing musical skills in autistic children who are not savants

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Descriptions of autistic musical savants suggest that they possess extraordinary skills within the domain. However, until recently little was known about the musical skills and potential of individuals with autism who are not savants. The results from these more recent studies investigating music perception, cognition and learning in musically untrained children with autism have revealed a pattern of abilities that are either enhanced or spared. For example, increased sensitivity to musical pitch and timbre is frequently observed, and studies investigating perception of musical structure and emotions have consistently failed to reveal deficits in autism. While the phenomenon of the savant syndrome is of considerable theoretical interest, it may have led to an under-consideration of the potential talents and skills of that vast majority of autistic individuals, who do not meet savant criteria. Data from empirical studies show that many autistic children possess musical potential that can and should be developed.

Keywords: autism; music; cognition; perception; savants

1. BACKGROUND

This paper focuses on music perception and cognition in that majority of children with autism who do not possess 'savant talent' as defined by Treffert (1989). Research on this topic was originally motivated by an interest in musical savants and questions about the cognitive characteristics that distinguish savants from autistic people without savant talent. However, findings from studies comparing non-savant autistic participants with age- and intelligence-matched controls revealed an intriguing pattern of enhanced and spared musical abilities. Consequently, this topic became interesting in its own right.

It was not only investigations sparked by the phenomenon of savantism that raised questions about unusual musical cognition in autism. Kanner, who first described autism in 1943, described several instances of extraordinary musical memory in his clinical group. Indeed, case reports of 6 of the 11 individuals described include descriptions of music-related behaviours that are extraordinary given their developmental levels. Particularly remarkable was case 9, who was able to discriminate between 18 symphonies and name their composers by 18 months. While Kanner's description has been hugely influential clinically, the potential functional significance of these children's intense and early preoccupation with music has been little considered. This may have been because their music-related behaviours were characterized as *rote memory* and assumed to be without affective or functional significance.

However, research shows that typical listeners learn about music simply by listening and it is clear that in this respect, the children in Kanner's group were similar to typical children: they learned by listening. Statistical learning, the mechanism that enables individuals to extract and represent higher-order domain-specific structures, from the stimuli to which they are exposed, has been widely implicated in music (e.g. Krumhansl *et al.* 2000), and it seems likely that the extraordinary musical memory abilities noted in Kanner's children were the end product of similar processes.

Nevertheless, while it is plausible to invoke 'typical' learning mechanisms, it also appears that early, atypically focused attention to and perception of music may differentiate at least some children with autism from those with typical development. Indeed, it is difficult to understand how case 9, described by Kanner, could have memorized such a large corpus of musical compositions were this not the case. The weak central coherence (WCC; Frith 1989; Happé 1999; Happé & Frith 2006) and enhanced perceptual functioning (Mottron & Burack 2001; Mottron *et al.* 2006) models of autism both hypothesize domain-general atypical perceptual and cognitive processing, and predictions from these models have been tested in a number of studies comparing music perception and cognition in autism and typical development. The findings from several of these studies have identified superior performance in autism, and these will be outlined in §2.

2. ENHANCED MUSIC PERCEPTION IN NON-SAVANT CHILDREN WITH AUTISM

The first study to identify superior performance on a musical task in autism was carried out by Applebaum *et al.* (1979). They observed that reproduction of atonal melodies was superior in the autistic child participants, compared with intellectually able typical children who had higher levels of musical experience. The second

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One contribution of 18 to a Discussion Meeting Issue 'Autism and talent'.

study to investigate musical pitch processing in autism (Heaton *et al.* 1998) tested the hypothesis that absolute pitch ability (AP), invariably observed in musical savants (Miller 1989), might also be more prevalent in autism. Motivated by Zatorre *et al.*'s (1998) suggestion that AP might reflect the ability to retrieve an arbitrary association between a pitch and a verbal label, children with autism and age- and intelligence-matched comparison children were presented with tones and animal pictures for paired learning. The findings from the study showed superior recall for the tone/animal pairings in the autism group. It was also noted that retrieval scores correlated with scores on the block design test from the Wechsler Intelligence Scales (Wechsler 1992), a test considered to be a marker for WCC (Shah & Frith 1993). It was therefore suggested that a local bias at the perceptual level (Happé 1999) was implicated in AP in autism.

However, while subsequent group and case studies replicated enhanced pitch identification in autism (Heaton *et al.* 1999*a*, 2008*a*; Bonnel *et al.* 2003; Heaton 2003), a significant positive correlation between pitch identification and block design scores was not observed, and this brought the positive association between AP and a local bias, as measured by the block design test, into question.

In typical populations, AP, or the ability to associate a pitch and a (usually verbal) label, is associated with the early onset of musical tuition. It is assumed that during early training the child focuses attention on tones and their corresponding note names and stores them in long-term memory (see Takeuchi & Hulse 1993). Increased attention to music, as suggested by Kanner's report, may enable autistic children to represent discrete, but unlabelled pitches in long-term memory. Anecdotal reports of autistic children remembering and reproducing environmental sounds are consistent with this suggestion. However, findings showing that autistic children, without musical training, can associate tones and retrieval labels in long-term memory (Heaton *et al.* 2008*a*) suggests that AP acquisition in autism and typical development is influenced by different processes. The suggestion that AP may be acquired by multiple routes is consistent with findings showing that the changes in functional anatomy (planum temporale) associated with AP in typical groups (e.g. Zatorre *et al.* 1998) are not observed in those with AP and congenital blindness (Hamilton *et al.* 2004). While abnormalities in planum temporale volumes have been observed in adults and children with autism (Rojas *et al.* 2002, 2005), the pattern of asymmetry is unlike that observed in typical AP possessors. As pitch naming skills were not tested in these studies, no conclusions about the neural correlates of AP in autism can be drawn.

If, as has been suggested, increased early attention to music is implicated in enhanced pitch memory in autism, fundamental questions about why such atypical attention is characteristic are worthy of investigation. In a recent study, J. L. Ward (2008, unpublished thesis) attempted to address this. She hypothesized that enhanced sensitivity to the perceptual components of music increases its reward value, thereby motivating increased listening.

Timbre refers to the colouristic aspects of sound. Orchestral music, written for a range of string, wind, brass and percussion instruments, provides an extremely rich palette of sounds. The timbre of a solo cello, violin or clarinet, or of a favourite singer's voice, can increase the listeners' aesthetic and emotional experience. Each instrument has its own particular sound, and Grey's multidimensional scaling model (Grey 1977) formalizes the degree of difference in psychoacoustic qualities between instruments.

In Ward's study, children with autistic spectrum disorder (ASD) and comparison children were presented with pairs of melodies and asked to say whether they were played by the same or different instruments. Different melody pairs were played by either *timbre-similar* (Bb bass clarinet and saxophone) or *timbre-dissimilar* (cello and soprano saxophone) instruments. The results from the study were analysed using signal detection theory and showed overall enhanced sensitivity to differences in timbre in the ASD group. Their pattern of discrimination performance was also different from that of controls. While controls were significantly better able to discriminate dissimilar from similar instruments, the ASD participants distinguished both types equally well. Thus, the largest between-group difference was observed when children were required to discriminate between instruments closely related in terms of timbre.

The findings from this study support the EPF theory of autism and also provide important clues about why some children with autism might show increased early attention to music. Perceptual information within creative domains, such as music (e.g. timbre) and art (e.g. colour), possesses considerable affective value. As Patel (2008) suggests 'a musical melody is a set of tones that love each other, a linguistic melody is a group of tones that work together to get a job done'. It may then be the case that increased sensitivity to these affectively rich aspects of sound increases listening and promotes enhanced pitch memory skills in some individuals. However, increased motivation to listen also increases the individual's opportunities to learn about other higher-order properties of music. In contrast to studies testing lower-order musical properties and showing enhanced performance in autism, experiments testing perception of higher-order musical properties have largely failed to identify differences between autism and control groups. These experiments will be discussed in the next section.

3. SPARED MUSIC PERCEPTION IN NON-SAVANT CHILDREN WITH AUTISM

In Frith's original formulation of the WCC theory (1989), she outlined a deficit in global processing. However, several studies directly addressed the question of whether a global deficit would impair music processing, and the findings showed that this is not the case. For example, in one open-ended experiment, where chords could be processed holistically or at the local (tone) level, a typical global bias was observed in the autism group (Heaton 2003). Similarly, when Gestalt preserving changes were made to one of a pair of melodies, participants with autism, like controls, judged that both melodies were the same (Heaton 2005). In a study by Mottron *et al.* (2000), autistic participants were also able to understand that when the second of a pair of melodies was presented in transposition (different notes/key) it was the same melody as the first (Mottron *et al.* 2000). It does not appear that a global deficit, at least as operationalized in these studies, characterizes music processing in autism.

One higher-order component of music that is relatively easy to define is its structure. The study of musical forms, e.g. sonata form and fugue, has long been part of the classical musician's training. However, as interest in music psychology has grown, researchers have turned their attention to questions about how musical structure is represented cognitively. This work has provided important insights into ways in which music perception parallels and differs from perception of other types of auditory stimuli, especially language (see Patel 2008). For example, experimental studies show that listeners' expectancies for upcoming musical events are primed by harmonic contexts at both global and local levels, with the former being most important (Tillman *et al.* 1998). This provides parallels with speech perception, where expectancies are primed by semantic content.

Using an adaptation of the sequential processing paradigm used by Tillman *et al.* (1998), we tested musically untrained children with ASD and typical development, and observed, in both groups, patterns of performance that were very similar to those observed when similar paradigms were tested with musically untrained adults. When individual target chords were preceded by sequences of seven chords to which they were harmonically related at global (chords 1–6) and local (chord 7) levels, our participants thought that they sounded correct. Numbers of 'correct' judgements fell when targets were related to the preceding context at the global level only, although these were still higher than when chords were related at the local level only. Targets were invariably judged to be incorrect when they were unrelated at global or local levels (Heaton *et al.* 2007).

This study showed that children with ASD acquire an understanding of the rules governing Western musical harmony. However, in a replication of this study, in which speed manipulations were carried out on the chord sequences (G. M. Nash 2008, unpublished thesis), some of the children with autism showed a temporal processing deficit. So, while a clear global bias was observed when stimuli were presented at a moderate tempo, this was lost and responses became random when stimuli were presented slowly. It was interesting that in a recent study carried out with high-functioning adults with ASD (Allen *et al.* 2009), 2 of the 12 participants in the study expressed a dislike for slow music, describing it as 'dirgey' and 'dirge-like'. This suggests that for a subgroup of individuals, temporal processing abnormalities result in a degree of musical impairment. However, the children in Nash's study showed no abnormalities when music was presented at moderate tempo, and the effects of such a difficulty may be limited to influencing a preference for faster music.

Other investigations tested the extent to which children with autism understand music's emotional connotations. The first of these examined perception of musical mode (Heaton *et al.* 1999*b*) and showed that children with autism were just as likely to pair fragments of major mode music with happy faces and fragments of minor mode music with sad faces as were age- and intelligence-matched controls.

In an extension of this study (Heaton *et al.* 2008*b*) we tested groups of typical 4- to 10-year-old children, musically naive adults, high- and low-functioning children and adolescents with autism and children and adolescents with Down syndrome. The task was to listen to extracts of music drawn from the classical orchestral repertoire and to match them with pictures depicting anger, fear, triumph, tenderness and contemplation. As a control condition, music and pictures depicting movement states (walking, running, gliding, climbing and jumping) were also presented for pairing. Our analysis of the data from the typical children and adults showed higher levels of music/picture matching for the feeling state conditions in comparison with the movement state conditions. Correct performance on the feeling state condition increased significantly from 4 to 6 years and from 6 to 8 years, at which point discrimination did not differ from that of musically untrained adults. The participants with Down syndrome showed poor performance on the task although it was significantly better than chance. The individuals in the ASD group performed well and, similar to typically developing participants, showed better identification of feeling state than of movement stimuli. When a regression analysis was carried out on the data, we found that performance was unaffected by diagnostic category and that verbal mental age explained much of the variance in the study. The results from our music screening questionnaire confirmed that good performance in the ASD group did not reflect increased musical exposure or training.

While sensitivity to music's affective and cultural connotations appears to depend on the extent to which language develops, sensitivity to other aspects of the musical language may be less dependent on language. In the study investigating the perception of musical structure (Heaton *et al.* 2007), groups were matched for chronological age and non-verbal intelligence, and verbal intelligence scores were not collected. While statistically significant group differences did not emerge in the study it is possible that mean verbal IQ scores were lower for the participants with autism suggesting that performance was enhanced relative to verbal mental age. While this is somewhat speculative, it is consistent with the findings from a recent study testing implicit learning of musical syntax. In this experiment, the autistic children were again matched to controls for chronological age and non-verbal intelligence, but tests of receptive vocabulary and grammar were also administered. The findings showed that the children with autism obtained significantly higher implicit learning test scores than controls even though their scores on the receptive vocabulary and grammar tests were significantly lower (J. L. Ward 2008, unpublished thesis).

4. WHY ARE AUTISTIC PEOPLE SO DRAWN TO MUSIC?

Temple Grandin has suggested that individuals with autism show a strong appreciation for musical structure, and Mottron *et al.* (2009) have provided a convincing account for why this might be the case. However, it should not be assumed that increased sensitivity to musical structure implies decreased sensitivity to music's affective qualities. Musicologists have long been interested in the relationship between the listeners' perception of structure, and his/her experience of emotion in response to this. Indeed, recent work by Huron (2006) suggests that is not really possible to disentangle musical structure and emotion, as the latter arises in direct response to the former. Mottron *et al.* (2009) suggest that pattern-rich, highly structured domains are affectively rewarding for people with autism and this provides a convincing explanation for why, for example, calendar calculating is so much more commonly observed in autism than in typical development.

However, music differs from calendars in important ways and consideration of these differences may provide insights into the question of why autistic people are so motivated to listen to music. First, 'lower level' musical information (e.g. timbre and groups of pitches) possesses rich affective qualities that may serve to 'capture' attention. Once attention is captured, statistical learning processes may come online and enable the individual to learn about music's higher-order characteristics. Although calendars and music share some organizational similarities, music may be distinguished by the extent to which perception of unfolding structure and experiences of emotion are linked (Mayer 1956; Huron 2006). Thus, while perceptual and cognitive accounts of autism continue to contribute much to our understanding of skills and talents in autism, the importance of affect in motivating autistic interests has yet be given full consideration. Recently, Berthoz & Hill (2005) identified type-II alexithymia, a disorder characterized by difficulties in verbally expressing emotions, in autistic adults. This raises interesting questions about how musical preoccupations might relate to difficulties in interpersonal domains.

5. THE PROBLEM OF UNEXPLOITED MUSICAL POTENTIAL IN AUTISM

While research into music cognition was originally motivated by an interest in musical savants, findings from studies testing children who do not meet criteria for savant skills suggest that they nevertheless possess considerable, but often unexploited, musical potential. For example, Heaton *et al.* (1999*a*) described the case of an adolescent boy with autism, who had AP and performed at ceiling on a battery of music analysis tasks. This individual had access to several instruments and carried a trumpet around with him but instrumental lessons had been very difficult to organize and his instrumental skills were negligible.

More recent data further address the question of unexploited musical potential in children with autism. In this study (Heaton *et al.* 2008*a*), high- and low-functioning children with autism completed tests of pitch discrimination and memory. The tasks required the children to map learned tones onto a visuospatial format (a staircase) for immediate and delayed retrieval. While the majority of the children with autism performed similarly to controls, scores for a subgroup of three children, comprising approximately 10 per cent of the sample, were between four and five standard deviations higher than those of the remaining autistic and typically developing participants. An analysis of the musical background data confirmed that their unusually accurate discrimination and memory skills did not reflect music lessons or a musically enriched environment. Indeed, their formal and informal opportunities to learn about music had been very limited. However, they all obtained high ratings for parental responses to the question 'How often does your child *choose* to listen to music at home?' and 'How would you rate your child's *reaction* to music?' Unfortunately, none of the children had been provided with the opportunity to learn to play a musical instrument, and the extent to which enhanced pitch analysis skills and increased self-motivated listening, would, if appropriately *scaffolded*, manifest in a talent for musical performance, is not known.

6. FUTURE DIRECTIONS

Descriptions of musical savants suggest that they acquire instrumental skills with minimal tuition, and sometimes with relatively limited access to musical instruments (Miller 1989). However, this is very unusual, and it would never be assumed that a typically developing child would develop musical skills without tuition and supported and extensive practice. Teaching music to children with social and communication difficulties poses special challenges for music educators. Nevertheless, there are several compelling reasons why such challenges should be met. First, there is some evidence that music instruction is associated with improvements in spatio-temporal processing (Hetland 2000), in some mathematical skills (Graziano *et al.* 1999) and in reading (Butzlaff 2000). Second, music serves important intrapersonal functions (Patel 2008). As one adult autistic participant in the study carried out by Allen *et al.* (2009) said, 'I find that sometimes if you're feeling very sad or something, listening to that kind of music can put you in touch with your feelings, it can help you to access your feelings. You can really feel the feelings instead of their just being there, you can really dwell in that state and deal with it.' Finally, music may convey interpersonal advantages. Children who sing, or play musical instruments, may increase their opportunities for social interactions, for example, by playing music in chamber groups and orchestras and singing in choirs.

Mottron *et al.* (2009) have suggested that there may be a particularly strong fit between the cognitive demands of savant domains and the pattern of strengths displayed by people with autism. The findings from the studies reviewed in this paper are consistent with this view. But it is also clear that for music, such strengths very rarely progress to skilled performance unaided. Children with autism, like typical children, need to be taught. The time therefore seems ripe to focus attention on how best this might be achieved.

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